L Number	Hits	Search Text	DB	Time stamp
1	4036450	data storage$1	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:23
2	16218	read adj write adj head$!	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:24
3	7597355	media surface$1	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:24
4	1153956	controller$1	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:25
5	3459787	predetermined track density	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:26
6	1953939	linear density	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:26
7	2734127	error code level near1 data	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:26
8	13619	(data storage$1) and (read adj write adj head$!)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:27
9	15839	(media surface$1) and ((data storage$1) and (read adj write adj head$!))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:28
10	880	controller$1 and ((media surface$1) and ((data storage$1) and (read adj write adj head$!)))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:28
11	6004033	(predetermined track density) or (linear density) or (error code level near1 data)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:29
12	817	(controller$1 and ((media surface$1) and ((data storage$1) and (read adj write adj head$!)))) and ((predetermined track density) or (linear density) or (error code level near1 data))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:35

13	2782885	maximum recordable track density	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:36
14	2965427	maximum recordable linear density	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:39
15	3326757	(maximum recordable track density) or (maximum recordable linear density)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:39
16	3944362	minimum recordable error code level near1 data	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:40
17	5991264	((maximum recordable track density) or (maximum recordable linear density)) or (minimum recordable error code level near1 data)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:40
18	749	((controller$1 and ((media surface$1) and ((data storage$1) and (read adj write adj head$!)))) and ((predetermined track density) or (linear density) or (error code level near1 data))) and (((maximum recordable track density) or (maximum recordable linear density)) or (minimum recordable error code level near1 data))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:47
19	2554817	magnetic head	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:47
20	7278716	magnetic surface	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:47
21	1873105	(magnetic head) and (magnetic surface)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:48
22	210	(((controller$1 and ((media surface$1) and ((data storage$1) and (read adj write adj head$!)))) and ((predetermined track density) or (linear density) or (error code level near1 data))) and (((maximum recordable track density) or (maximum recordable linear density)) or (minimum recordable error code level near1 data))) and ((magnetic head) and (magnetic surface))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:51
23	364382	compar$3 and (quality metric with reference metric)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:54
24	75	((((controller$1 and ((media surface$1) and ((data storage$1) and (read adj write adj head$!)))) and ((predetermined track density) or (linear density) or (error code level near1 data))) and (((maximum recordable track density) or (maximum recordable linear density)) or (minimum recordable error code level near1 data))) and ((magnetic head) and (magnetic surface))) and (compar$3 and (quality metric with reference metric))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:56

25	2859107	acceptable error rate$1	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:56
26	70	((((((controller$1 and ((media surface$1) and ((data storage$1) and (read adj write adj head$!)))) and ((predetermined track density) or (linear density) or (error code level near1 data))) and (((maximum recordable track density) or (maximum recordable linear density)) or (minimum recordable error code level near1 data))) and ((magnetic head) and (magnetic surface))) and (compar$3 and (quality metric with reference metric))) and (acceptable error rate$1)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:56
27	324749	measur$3 with (((predetermined track density) or (linear density) or (error code level near1 data)))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:59
28	15	(((((((controller$1 and ((media surface$1) and ((data storage$1) and (read adj write adj head$!)))) and ((predetermined track density) or (linear density) or (error code level near1 data))) and (((maximum recordable track density) or (maximum recordable linear density)) or (minimum recordable error code level near1 data))) and ((magnetic head) and (magnetic surface))) and (compar$3 and (quality metric with reference metric))) and (acceptable error rate$1)) and (measur$3 with (((predetermined track density) or (linear density) or (error code level near1 data))))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 13:59
29	148307	program$4 and (write data with (measur$3 with (((predetermined track density) or (linear density) or (error code level near1 data)))))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 14:00
30	4	((((((((controller$1 and ((media surface$1) and ((data storage$1) and (read adj write adj head$!)))) and ((predetermined track density) or (linear density) or (error code level near1 data))) and (((maximum recordable track density) or (maximum recordable linear density)) or (minimum recordable error code level near1 data))) and ((magnetic head) and (magnetic surface))) and (compar$3 and (quality metric with reference metric))) and (acceptable error rate$1)) and (measur$3 with (((predetermined track density) or (linear density) or (error code level near1 data))))) and (program$4 and (write data with (measur$3 with (((predetermined track density) or (linear density) or (error code level near1 data))))))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 14:02
31	11356	714/774.ccls. or 714/?.ccls. or 360/?.ccls. or 369/?.ccls. or 365/?.ccls. or 386/?.ccls.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 14:04

US006215898B1

(54) **DATA PROCESSING SYSTEM AND METHOD**

(75) Inventors: **John Iselin Woodfill**, San Francisco; **Henry Harlyn Baker**, Los Altos, both of CA (US); **Brian Von Herzen**, Carson City, NV (US); **Robert Dale Alkire**, San Jose, CA (US)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,905,081	2/1990	Morton .	
5,179,441	1/1993	Anderson et al. .	
5,454,064	9/1995	Castelaz .	
5,652,616	7/1997	Chen et al.	348/43
5,719,954	2/1998	Onda	382/154
5,727,078	3/1998	Chupeau	382/154
5,764,871	6/1998	Fogel .	
5,767,922	6/1998	Zabih et al. .	
5,768,404	6/1998	Morimura et al.	382/107

OTHER PUBLICATIONS

Baker, et al., "Realtime Stereo and Motion Integration for Navigation", ISPRS Commission III, IC Working Group V/III, pp. 17–24, not dated.

Hannah, "Computer Matching of Areas in Stereo Images", Dissertation, pp. 1–126, 1974.
Kanade, et al., "A Stereo Machine for Video–Rate Dense Depth Mapping and Its New Applications", Robotics Institute, Carnegie Mellon Univ., pp. 196–202, 1996.
Kanade, et al., "Development of a Video–Rate Stereo Machine", Robotics Institute, Carnegie Mellon Univ., 1995.
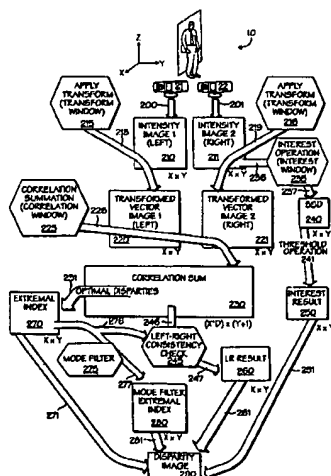
(List continued on next page.)

(57) **ABSTRACT**

A powerful, scaleable, and reconfigurable image processing system and method of processing data therein is described. This general purpose, reconfigurable engine with toroidal topology, distributed memory, and wide bandwidth I/O are capable of solving real applications at real-time speeds. The reconfigurable image processing system can be optimized to efficiently perform specialized computations, such as real-time video and audio processing. This reconfigurable image processing system provides high performance via high computational density, high memory bandwidth, and high I/O bandwidth. Generally, the reconfigurable image processing system and its control structure include a homogeneous array of 16 field programmable gate arrays (FPGA) and 16 static random access memories (SRAM) arranged in a partial torus configuration. The reconfigurable image processing system also includes a PCI bus interface chip, a clock control chip, and a datapath chip. It can be implemented in a single board. It receives data from its external environment, computes correspondence, and uses the results of the correspondence computations for various post-processing industrial applications. The reconfigurable image processing system determines correspondence by using non-parametric local transforms followed by correlation. These non-parametric local transforms include the census and rank transforms. Other embodiments involve a combination of correspondence, rectification, a left-right consistency check, and the application of an interest operator.

40 Claims, 153 Drawing Sheets

L Number	Hits	Search Text	DB	Time stamp
1	1019544	electrically erasing data near1 block adj block	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:30
2	1258691	electrically writing data near1 unit adj unit	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:30
3	986131	(electrically erasing data near1 block adj block) and (electrically writing data near1 unit adj unit)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:30
4	1498489	nonvolatile memory	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:31
5	164557	((electrically erasing data near1 block adj block) and (electrically writing data near1 unit adj unit)) and (nonvolatile memory)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:32
6	3870834	single semiconductor chip	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:32
7	130778	(((electrically erasing data near1 block adj block) and (electrically writing data near1 unit adj unit)) and (nonvolatile memory)) and (single semiconductor chip)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:33
8	4713681	electrical signal$1	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:34
9	114438	((((electrically erasing data near1 block adj block) and (electrically writing data near1 unit adj unit)) and (nonvolatile memory)) and (single semiconductor chip)) and (electrical signal$1)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:35
10	7989695	signal process$3	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:36
11	112085	(((((electrically erasing data near1 block adj block) and (electrically writing data near1 unit adj unit)) and (nonvolatile memory)) and (single semiconductor chip)) and (electrical signal$1)) and (signal process$3)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:38
12	122205	check$3 and (data with error$1 or reliability)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:40

13	13573	((((((electrically erasing data near1 block adj block) and (electrically writing data near1 unit adj unit)) and (nonvolatile memory)) and (single semiconductor chip)) and (electrical signal$1)) and (signal process$3)) and (check$3 and (data with error$1 or reliability))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:42
14	2354290	rewrit$3 data and erased block$1	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:43
15	12461	(((((((electrically erasing data near1 block adj block) and (electrically writing data near1 unit adj unit)) and (nonvolatile memory)) and (single semiconductor chip)) and (electrical signal$1)) and (signal process$3)) and (check$3 and (data with error$1 or reliability))) and (rewrit$3 data and erased block$1)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:44
16	3494049	prescribed area	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:44
17	9894	((((((((electrically erasing data near1 block adj block) and (electrically writing data near1 unit adj unit)) and (nonvolatile memory)) and (single semiconductor chip)) and (electrical signal$1)) and (signal process$3)) and (check$3 and (data with error$1 or reliability))) and (rewrit$3 data and erased block$1)) and (prescribed area)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:44
18	159100	microcomputer$1	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:44
20	10228133	control device$1	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:45
21	10253808	microcomputer$1 or (control device$1)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:48
22	9	(((((((((electrically erasing data near1 block adj block) and (electrically writing data near1 unit adj unit)) and (nonvolatile memory)) and (single semiconductor chip)) and (electrical signal$1)) and (signal process$3)) and (check$3 and (data with error$1 or reliability))) and (rewrit$3 data and erased block$1)) and (prescribed area)) and (microcomputer$1 or (control device$1))	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:48
23	6467766	user data storage area	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:49
24	9	((((((((((electrically erasing data near1 block adj block) and (electrically writing data near1 unit adj unit)) and (nonvolatile memory)) and (single semiconductor chip)) and (electrical signal$1)) and (signal process$3)) and (check$3 and (data with error$1 or reliability))) and (rewrit$3 data and erased block$1)) and (prescribed area)) and (microcomputer$1 or (control device$1))) and (user data storage area)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2004/06/11 19:50